INVERTEBRATES IN MONITORING ENVIRONMENTAL QUALITY AND CHANGE

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INTRODUCTION

Environmental monitoring, of wildlife rather than chemical factors, has tended to concentrate on plants and birds as indicators of quality (e.g. Ratcliffe, 1977; authors in Goldsmith, 1991), with relatively little regard being taken of invertebrates, which make up by far the largest numbers of species in any given environment. As there are considerable numbers of invertebrates at any given site, it is very likely that some invertebrate groups will be useful in environmental monitoring. There has been recent work on a number of groups of invertebrates, both terrestrial and freshwater, with a view to their use in assessing environmental quality and investigating change with time. Invertebrates can be used to assess sites for conservation (Luff, 1987; Foster, 1991), for pollution monitoring (e.g. Moss *et al*., 1987), for investigating land management effects (e.g. Rushton *et al.,* 1989) and there is some work indicating the possibility of their use in investigating changes brought about by, for instance, climate change (Watt, Ward & Eversham, 1990).

SITE QUALITY ASSESSMENT

Several of the conservation criteria outlined by Ratcliffe (1977) are difficult or impossible to quantify, but for routine site assessment criteria must be quantifiable, so that sites can be ranked; some criteria can be quantified using invertebrate data.

Diversity

There are many diversity indices which take into account both the number of individuals and the number of species. The simplest measure of diversity is species richness, but this, and diversity indices, still present problems when used for invertebrates. The number of invertebrate species recorded from a particular site tends to be dependent on the amount of sampling effort, and comparisons of site lists can be misleading if the sampling techniques and effort have not been the same. Thus, standardized techniques are required using the same time period. One such method is pitfall trapping, as outlined by Luff, Eyre & Rushton (1992). Other trapping techniques, such as interception traps, may also be applicable, but care needs to be taken as to the group of invertebrates for which they are used. It is essential to have sufficient knowledge of the taxonomy, ecology and biology of the group before they can be used in site assessment.

Rarity

Rarity is the most easily understood and most 'political' assessment criteria, and the one where biological recording can be used to best advantage. Ball (1986) produced a list of the rare invertebrates in Great Britain, which could be used in an invertebrate index, but good distribution data are essential for such an index and this factor will restrict the number of invertebrate groups which can be used. Work on the quantification of rarity, and on the production of rarity indices, has been carried out for water beetles and ground beetles. Foster (1987) proposed the use of a species rarity index based on the UK national water beetle recording scheme and this was used by Foster *et al*. (1989) to assess the quality of drain sites in eastern England and by Foster & Eyre (1992) to rank sites in a number of areas of the UK. On a regional basis, Eyre & Rushton (1989) produced rarity indices for both water and ground beetles in north-east England. A calculation of rarity association was also attempted with regional tetrad (2 x 2 km) data (Eyre, Ball & Foster, 1985; Eyre, Luff & Ball, 1986), to emphasize those sites with rare assemblages. Using these indices, sites can be ranked in water and ground beetle habitat types generated from classifications (Eyre, Ball & Foster, 1986; Luff, Eyre & Rushton, 1989). A classification of British grassland ground beetle habitats (Eyre & Luff, 1990a) should enable a national rarity index, based on the forthcoming carabid atlas, to be used to rank sites on a national basis.

Typicalness

One of the objectives outlined by Ratcliffe (1977) was to conserve good examples of habitat type. This is a difficult criterion to quantify without the complex ordination technique used by Eyre and Rushton (1989), which may preclude general application. Usher (1980) asserted that there was a relationship between rarity and typicalness, in that the presence of rare species at a site meant that a site could not be typical, but this was found not to be the case (Eyre & Rushton 1989) because rare species can be archetypical in a rare habitat.

Naturalness

For an assessment of site naturalness to be made, knowledge is needed of a previous, more 'natural', situation. In north-east England considerable entomological recording was carried out by James Hardy and Thomas Bold between 1843 and 1875. They published information for several sites, so that lists of beetle species can be compiled from a time before the sites were developed for agriculture, mining or building. The recent classifications of both water and ground beetles in north-east England can be used to place historical records into a perspective of habitat and temporal change. Foster (1992) showed the changes through time at two sites in north-east England (Figure 1). Boldon Flats changed from a lake in the 1850s to a pond in the 1930s to temporary water in the 1980s whereas Prestwick Carr went from a transition mire in the 1850s to a pond in the 1970s to a marsh in the 1980s. There has been attempts, at Boldon Flats, to construct a more 'natural' situation by digging a permanent pond and the results can be monitored using water beetles.

ASSESSING ENVIRONMENTAL CHANGE

Land management

Land management has been shown to affect the distribution of species in several invertebrate groups and there is potential for using these animals to monitor land use change. Most work has been carried out using pitfall traps and on the effects of management on ground beetles and spiders. Rushton, Luff & Eyre (1989) investigated the effects of upland pasture improvement by physical means and by pesticide application and found that both ground beetle and spider assemblages reflected change. Agricultural management dictates the distribution of ground beetles (Rushton, Eyre & Luff, 1990a; Eyre, Luff & Rushton, 1990), spiders (Rushton & Eyre, 1989, 1992) and, to a lesser extent, weevils (Luff & Eyre, 1988; Eyre *et al*. 1989). The management of nature reserves is also

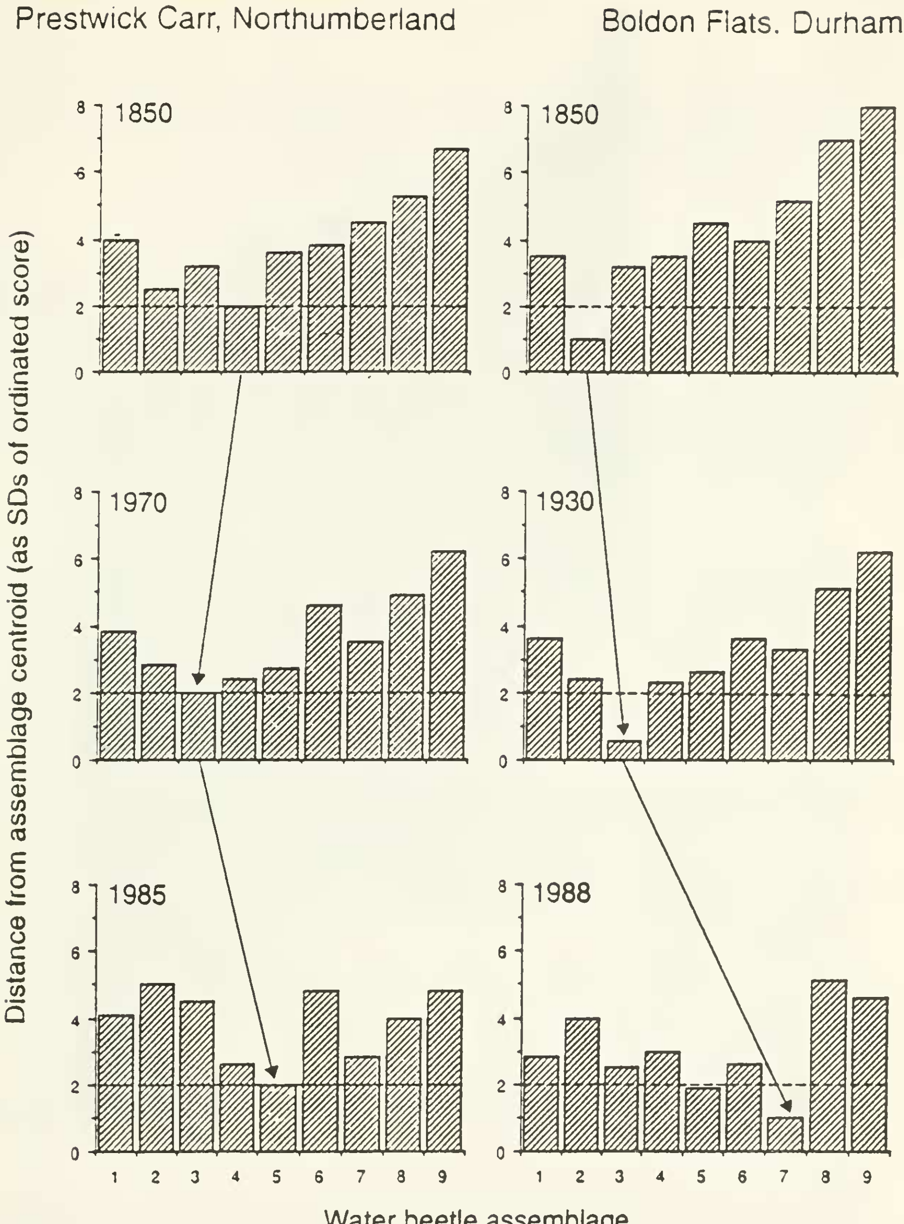

Figure 1. Changes with time in the water beetle assemblages at two sites in north-east England to the nine habitat groups recognized; 2=lakes, 3=lowland ponds, 4=transition mires, 5=marshes, 7=temporary water (from Foster, 1992).

reflected by spider and ground beetle assemblages (Rushton, 1988; Rushton, Eyre & Luff, 1990b).

In the Countryside 1990 Survey, carried out by the Institute of Terrestrial Ecology (ITE), the incidence of water beetle species in 1-km national grid squares has been shown to reflect land cover at the 1-km square level and Foster (1992) described how land use practices affect water beetle distribution. This work opens up the possibility of using water beetles to monitor land use changes at the landscape scale.

Pollution monitoring

The possibility of using river and stream invertebrates for monitoring the effects of water pollution and for assessing the environmental effects of acid precipitation has been investigated. The work of Wright *et al.* (1984) was developed by Moss *et al.* (1987) and Wright *et al.* (1989) to produce a system to predict invertebrate assemblages given a set of environmental factors. This system is now in use in each of the National River Authority regions to identify lengths of river which are polluted, so that remedial action can be taken. Water acidification in Wales has been investigated using stream invertebrates (Ormerod & Edwards 1987; Ormerod & Wade, 1990) so that predictions of change can be made (Wade, Ormerod & Gee 1989).

Climate change

The potential for using invertebrates for assessment of changes due to climate fluctuation must be great given the ability of some groups to adapt rapidly by colonization. Watt, Ward & Eversham (1990) outlined some possible changes and noted a relationship between the distribution of numbers of dragonfly species and a spring isotherm. The distribution of water beetles has been related to climate in northern England and southern Scotland. The distribution of *Colymbetes fuscus*, based on a climate index derived from temperature, rainfall, windspeed and sunshine hours, is shown in Figure 2. Potential changes in distribution brought about by an increase in temperature, sunshine hours and windspeed and a decrease in rainfall can be predicted and the potential changes in *C.fuscus* distribution are shown in Figure 3. However, the effects of climate change are more likely to be at the ecosystem level (Cannell & Hooper, 1990) with considerable changes in land use (Parry & Carter, 1989). These changes will effect niche availability and environmental factors such as water availability, water acidity, soil structure and land cover. An understanding of the environmental factors which limit species distribution is required and this will limit the use of invertebrates to those group for which knowledge is adequate.

One change likely to occur if there is an overall rise in temperature, and therefore evapotranspiration, is a change from permanent to temporary water. Eyre *et al.* (1992) have shown that water beetle species differ in their response to temporary water conditions and differ between larval and adult stages. Species preferring temporary water are likely to be favoured by a temperature increase and permanent water species detrimentally affected. Changes in soil chemistry are probable with climate change, with increased turnover of organic matter and rock weathering (Ineson & Stevens, 1990). This may lead to a reduction in acidic water conditions. Water pH is a major factor affecting invertebrate distribution in both static (Eyre, Foster & Foster, 1990) and running water (Sutcliffe & Hildrew, 1989) and a change away from acid conditions will favour groups of invertebrates such as mayflies.

Soil turnover rates and evaporation will also affect the distribution of ground beetle species. Rushton, Luff & Eyre (1991) and Luff, Eyre & Rushton (1992) have shown that soil water is a major determinant of carabid beetle distribution. Eyre & Luff (1990b) have shown that the continental distribution of some species of ground beetle is different from the British distribution. Species found on coastal sand in Britain, such as *Broscus cephalotes*, are found in the middle of the European land mass on very dry, brittle soils and it may be that these conditions will be produced in inland Britain and distributions of some

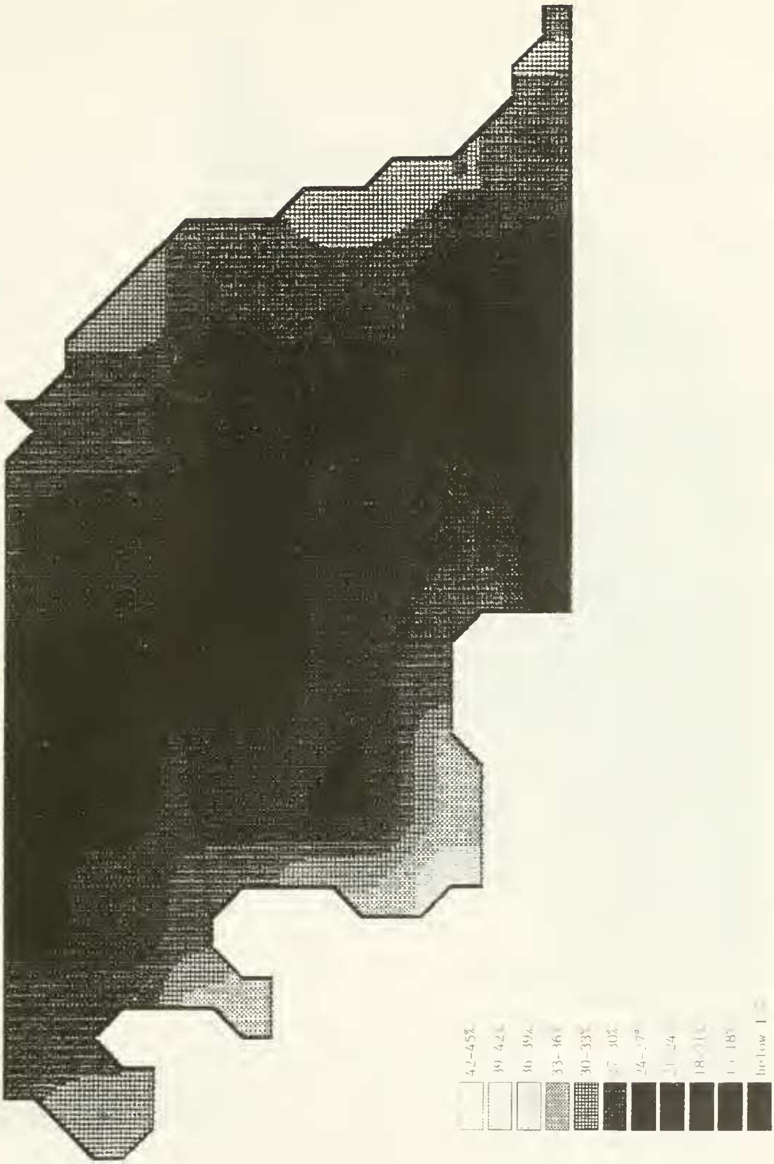

Figure 2. Interpolation of the distribution of *Colymbetes fuscus* derived from the climate index.

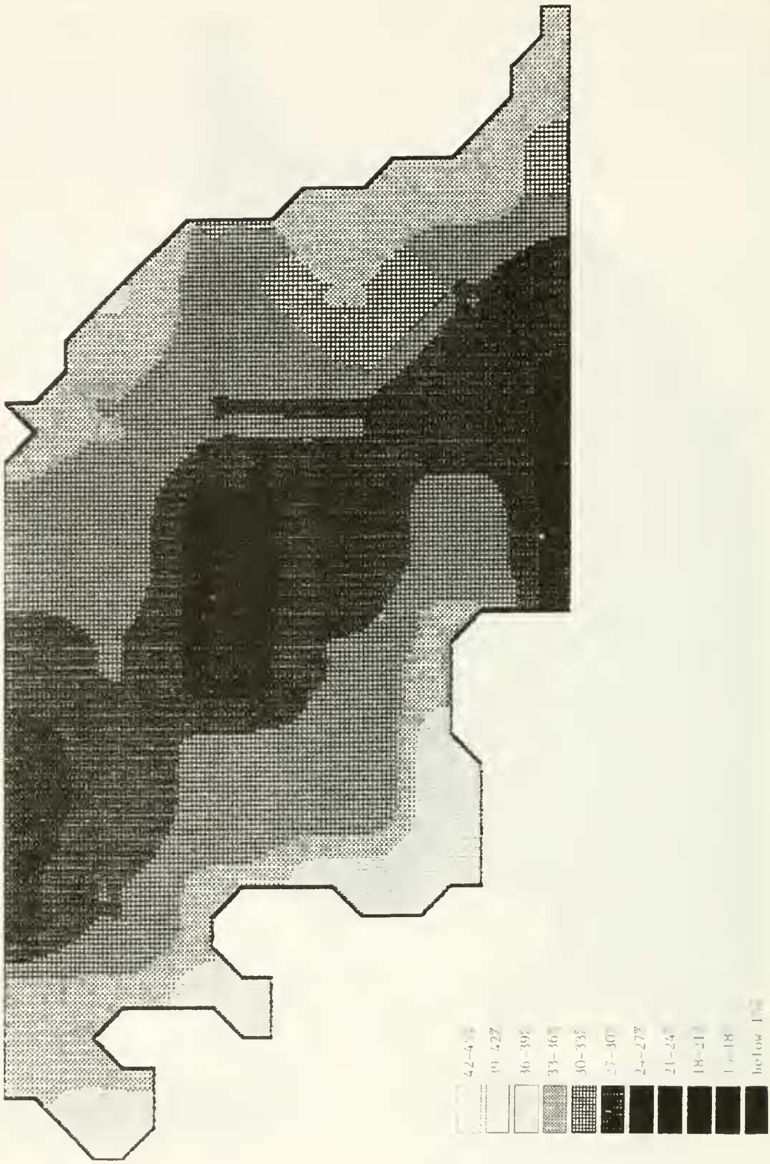

Figure 3. Interpolation of the potential distribution of *Colymbetes fuscus* given a change in climate (see text).

beetle species changed. If climate changes affect land use, land cover will change and this will also be reflected in ground beetle distributions.

CONCLUSIONS

1 The potential for using invertebrates in environmental monitoring is considerable.
2 Invertebrates can be used for both assessing site quality and for investigating environmental change.
3 Species in some groups are good indicators of site relic status and the information gathered by both national and local recording schemes is of paramount importance in assessing site quality.
4 There is a requirement for adequate knowledge of an invertebrate group's taxonomy, biology and ecology before they can be considered in monitoring environmental change.
5 The use of invertebrate groups for environmental monitoring will be limited to those which can be sampled with relative ease and identified accurately.
6 Environmental change brings about habitat modification and the most important requirement is for a knowledge of the distributional strategies of individual species or species assemblages. Changes in invertebrate distributions can then be related to changing environmental conditions.

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